

REMARKS

In the Office Action dated November 20, 2006, the Examiner notes that claims 2-6 are pending in the application. By this amendment, claims 2-6 have been amended and new claims 7 and 8 have been added. The amendments to the claims and the new claims are fully supported by the specification and do not add any new matter to the application. Therefore, claims 2-8 are currently pending in the application.

In the Office Action, the Examiner: (1) objected to the specification; (2) rejected claims 2-6 under 35 USC §112, second paragraph; and (3) rejected claims 2-6 under 35 USC §103(a). Applicant responds to the Examiner's rejections below.

Objection to the Specification

The Examiner objected to the Specification because the Examiner believes that the Specification fails to provide proper antecedent basis for the claimed subject matter. Applicant respectfully submits that the above amendment addresses this objection and respectfully requests that this objection be withdrawn. Support for the above amendment to the Specification can be found in claims 15 and 17 of the originally filed parent application, US Patent Application No. 10/172,848, filed June 17, 2002 (now US Patent No. 6,669,823, issued December 30, 2003).

Claim Rejections – 35 USC §112, Second Paragraph

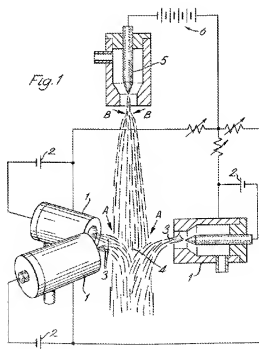
The Examiner rejected claims 2-6 under 35 USC §112, second paragraph, because the Examiner believes the claims are indefinite for failing to particularly point out and distinctly claim the subject matter which Applicant regards as the invention. Applicant respectfully submits that the above amendments overcome this rejection.

Claim Rejections - 35 USC §103(a)

The Examiner also rejected claims 2, 3, 5, and 6 under 35 USC §103(a) as being unpatentable over US Patent 3,989,512 (“Sayce”) in view of US Patent 5,788,738 (“Pirzada”). Applicant respectfully traverses this rejection.

As to independent claim 2, neither Sayce nor Pirzada disclose or suggest “injecting a precursor material into the plasma through at least one of a current carrying region of an anodic column and a current carrying region of a cathodic column” as recited in claim 2.

As for Sayce, Sayce does not disclose or suggest injecting a precursor material through a current carrying region of an anodic or cathodic column. Rather Sayce teaches a method of generating a *constricted arc column* having a conventional wall-stabilized arc and introducing the precursor material into the plasma in either regions A or B of Fig. 1. (see Sayce, col. 5, ll. 16-19, and Fig. 1 (reproduced below)).



Sayce, Fig. 1

However, introduction of the precursor material into the plasma at regions A or B will not inject the precursor material into the *current carrying region of the anodic or cathodic column*. Instead, the precursor material injected in regions A and B will merely traverse the cool, non-conducting gas film adjacent to the current carrying arc column. This is further shown in Sayce when it is disclosed that the precursor material in Sayce will be heated to 1,600-2,000°C (see col. 3, l. 39), which is the approximate temperature of the gas film adjacent the current carrying arc column, rather than the approximately 10,000°K that is associated with the current carrying arc column.

The only region that a precursor material can be successfully injected into a current carrying region of an arc column is at the injection window, which is directly adjacent the cathode. However, use of a constricted arc column, such as those disclosed in Sayce, enclose the area directly adjacent the cathode and thereby make the injection window inaccessible. Therefore, it is not possible to inject a precursor material into the current carrying region of an arc column when constricted arc columns are used, as in Sayce.

US Patents 3,644,782 ("Sheer II") and 3,644,781 ("Sheer I") summarize the conditions that are required to introduce precursor materials at the anode and the processing conditions required for introducing non-gaseous precursor material into the cathodic arc column (the negatively charged column extending from the cathode tip).

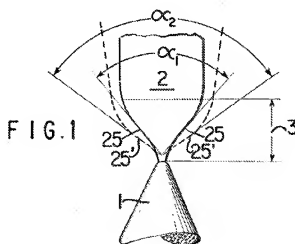
The following is taken from Sheer I:

"It has long been known that when an arc is struck between an anode and a cathode having a conical tip, as illustrated in FIG. 1 [reproduced below], there occurs a contraction in the current-carrying area in the transition region between the cathode 1 and the column proper 2. This contraction is indicated as the contraction zone 3. This contraction of the current-carrying area in the transition region between the cathode 1 and the column proper 2 may also be defined by the angle α which is determined by extending lines tangent to the column boundary at

the points of inflection 25 of the contraction. This contraction causes the natural cathode jet effect as explained in the following.

Referring to Fig 1, the current density, and therefore, the self-magnetic field due to the arc current, increases toward the cathode as a result of the contraction. This nonuniform magnetic field exerts a body force on the conductive plasma, propelling it in the direction of maximum decrease in magnetic field, i.e., along the arc axis away from the cathode tip. The streaming of plasma away from the cathode tip decreases the local pressure in the immediate vicinity of the cathode tip and causes the arc to aspirate gas from the surrounding atmosphere. This mechanism establishes the well-known cathode jet, which has been observed to flow along the axis of the column away from the cathode tip in all arcs characterized by a contraction zone adjacent to the cathode.

In our concurrently filed U.S. Pat. application Ser. No. 1,388 [Sheer II], we show that this contraction zone 3 can serve as an "injection window" across which a fluid medium in the form of a gas may be injected directly into the arc column 2 at flow rates in excess of what can be forced across the cylindrical column boundary of the arc. Gas flow rates of a magnitude much greater than that aspirated naturally can be injected into the column without disturbing the stability of the arc when the gas is forced to follow the conical configuration of the cathode tip. However, the increase in gas convection rate does effect the angle α and if the angle α is reduced below 40° , no substantial amounts of additional gas can be injected into the column 2. In short, the injection of a copious stream of gas into the column through the "injection window" is not only possible but actually increases the heat transfer effectiveness of this part of the arc, as long as it does not exceed the convection rate which will reduce the angle α below 40° ." (Sheer I at col. 4, ll. 2-50)



Sheer I, Fig. 1

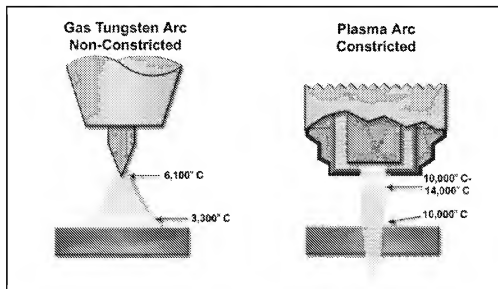
As disclosed in Sheer I, it is possible to inject a heterogeneous stream consisting of carrier gas in which entrained liquid droplets or solid particles (precursor materials), and that said liquid or solid particulates will be carried through the "injection window" along with the carrier gas to mingle with the column and be exposed to the high temperature environment therein (Sheer I at col. 6, ll. 7-15). An increase in the convection rate of heterogeneous material, while the gaseous material being introduced is held at a constant convection rate, causes an enlargement of the window angle, shown as α_2 in Figure 1 above (see also col. 6, ll. 36-42).

However, it is not possible to inject a working fluid into the current carrying interior of an arc column at points other than the anode or "injection window" at the transition region between the cathode and the column proper as detailed in Sheer I. Sheer I provides the following examples.

"Attempts have also been made to inject a working fluid into the interior of an arc column at other points than the anode. Many difficulties have been found in these attempts. For example, in a constricted arc column having a conventional wall-stabilized arc with a segmented, water-cooled constrictor channel long enough to assure the establishment of a fully developed column, the injected gas was forced to flow axially, concentric and parallel to the conduction column. Since the column in this device is subject to an appreciable thermal constriction, it would seem that a convected gas would be forced through the column boundary into the primary energy-dissipating zone. It was found, however, that, even in the fully developed region, beyond which the radial distributions of the flow parameters remain constant, by far the major part of the flow traverses the thin, cool, non-conducting gas film adjacent to the [conduction] channel wall. In fact only about 10 percent of the mass flow enters the hot core. The much higher density and lower viscosity of the cool gas in the wall layer, plus the fact that even a very thin film can have appreciable cross-sectional area near the wall, compensate for the lower velocity of the cool gas layer, and account for nearly all of the convected mass flow. It should be noted that the radial temperature across the fully developed portion of the column remains above 10,000°K. over 80 percent of the channel diameter, so that the plasma fills the channel quite well. The conclusion is that most of the working fluid does not penetrate the column and is therefore not directly exposed to the zone of maximum energy dissipation.

The same effect is noted with other flow configurations. For example, is a stream of gas is projected at right angles to the column of a free-burning arc, the arc will be blown out at quite low flow rates. [Even if the arc column can be stabilized by a magnetic field of suitable strength,] at very high flow rates, the gas does not enter the column, but is deflected around it, the column behaving much like a solid cylinder." (Sheer I at col. 2, l. 52 to col. 3, l. 15)

Therefore, in order to inject a gas containing a liquid or solid precursor material into the current carrying region of a column the precursor material must be injected into the "injection window" at the tip of the cathode, which is not accessible when a constricted arc column is used. Constricted arc columns are employed to stabilize the arc as shown in the figure below (see MILLER ELECTRIC, Plasma Theory, page 2).



A non-constricted transferred arc plasma expands in volume and pressure and effectively spreads as shown to the left in the figure above. Conversely, if the plasma arc is constricted the arc does not expand and plasma temperatures are higher, but the transition region between the cathode and the column proper is enclosed and the "injection window" is not accessible.

A more detailed schematic of a constricted, non-transferred plasma torch as those used by Sayce is shown below (see LE, HE-PING ET AL., J. Phys. D: Appl. Phys. 36 (2003) 1084-1096).

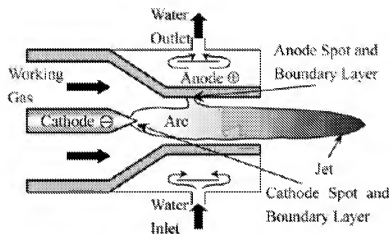


Figure 1. Schematic diagram of the non-transferred DC arc plasma torch.

Therefore, although Sayce discloses a constricted arc column to stabilize the plasma, the “injection window” in the Sayce device in the region of contraction in the current-carrying area in the transition region between the cathode and the column directly adjacent to the cathode spot is closed and precursor material is not and cannot be introduced into the current-carrying region of the plasma. In essence, Sayce is only a heater assembly as recited in claim 1 of Sayce.

Furthermore, Sayce actually teaches away from what is recited in claim 2 of the above application. Example 1 is Sayce states that heat treatment is carried out in an oxidizing atmosphere in order to *suppress vaporization* of the oxide (Sayce at col. 6, ll. 66-68). Conversely, the above application uses an oxidizing gas in the plasma and introduces precursor materials into the current-carrying region of the plasma (the “active volume”) *where they are vaporized*.

As for Pirzada, Pirzada does not disclose or suggest injecting a precursor into a plasma at all. In Pirzada, a plasma is used to heat the thermal reactor that the precursor material passes through, however, the precursor material is never injected into the plasma.

Therefore, even if such a combination as Sayce and Pirzada were made, which Applicant does not concede is proper, the purported combination still would not reflect all of the elements recited in claim 2. Claims 3, 5, and 6 depend from independent claim 2 and for the reasons stated above are also patentable over Sayce in view of Pirzada.

The Examiner also rejected claim 4 under 35 USC §103(a) as being unpatentable over Sayce in view of Pirzada and further in view of Applicant's admission. Applicant respectfully traverses this rejection.

Claim 4 depends from independent claim 2. As discussed above for independent claim 2, neither Sayce nor Pirzada disclose or suggest "injecting a precursor material into the plasma through at least one of *a current carrying region of an anodic column and a current carrying region of a cathodic column*" as recited in claim 2. In addition, the "Applicant's admission" referred to by the Examiner also does not disclose or suggest "injecting a precursor material into the plasma through at least one of *a current carrying region of an anodic column and a current carrying region of a cathodic column*."

Therefore, even if such a combination as Sayce, Pirzada, and Applicant's admission were made, which Applicant does not concede is proper, the purported combination still would not reflect all of the elements recited in claim 4.

Conclusion

In view of the aforesaid, Applicant respectfully submits that claims 2-8 are in condition for allowance and a Notice of Allowance for these claims is respectfully requested.

Respectfully submitted,

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